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Cooperation Between Science Teachers and ESL Teachers: A Register Perspective


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Cooperation Between Science Teachers and ESL Teachers: A Register Perspective

Abstract

Cooperation between English as a second or other language (ESOL) and content-area teachers, often difficult to achieve, is hard to assess linguistically in a revealing way. This article employs register analysis (which is different from, but complementary to, genre analysis) in a Systemic Functional Linguistic perspective to show how an ESOL teacher uses the same content-area task as a cooperating science teacher so that she can provide a theory–practice cycle similar to that of the science teacher, but at a level that reflects and builds on the language abilities of her students. The task allows her to assess her students formatively and help them develop relevant meanings in the register of science. We argue that the development of register through related tasks in content classes and language classes provides a principled basis for cooperation and that register analysis offers revealing insights into cooperation and formative assessment between language and content teachers.

Disciplines

Educational Assessment, Evaluation, and Research | Language and Literacy Education | Science and Mathematics Education

Comments

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Cooperation between science teachers and ESL teachers: A register perspective

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Introduction

The progress of English language learners (ELLs) in the content areas requires skillful cooperation between their content teachers and English as a second language (ESL) teachers. A recent review of research on teaching ELLs in the content areas (Janzen, 2008) found that children of immigrants make up 20 percent of the population of US schools, and that those who are ELLs are at a high risk of academic failure. Content areas require academic literacy, not just a basic knowledge of the language code, and “studies based on SFL (Systemic Functional Linguistics) represent the most compelling perspective on content-area instruction, doubtless because they start from an extensively developed stance on the nature of language in general” (p. 1015). A critical issue is that most content-area teachers are not trained to work with ELLs, and cooperation between ESL and content-area teachers is urgently required. Various challenges prevent “meaningful in-service cooperation” (p. 1030), and thus studies of “best practices” of cooperation are needed. In this article we will show how an ESL teacher and a science teacher cooperated skillfully through their use of science tasks that applied theory to practice and helped students develop relevant meanings in the register of science.

Theoretical framework

To address the needs of ELLs, we need a framework that addresses language as a means of learning. Systemic Functional Linguistics (SFL) does this by providing the theory and tools to

analyze the development of academic language and meaning. SFL views language as the primary means of learning about the world. It views knowledge as meaning, a resource for understanding and acting on the world, and it sees learning as a process of making meaning (see Halliday & Matthiessen, 1999). In other words, SFL considers learning in linguistic terms, which means that content teaching and learning can be examined by looking at the classroom interaction discourse that occurs as teachers work on developing meaning

Two concepts of SFL that elaborate the theme of language as a means of learning are *genre* and *register*. These are two lenses that frame different aspects of this theme. A genre is “a staged, goal-oriented, social process” (Martin & Rose, 2003, p. 7), and some of the prototypical genres of schooling are Recount, Narrative, Procedure, Report, Account, Explanation, and Exposition (see Schleppegrell, 2004). Genre is a well-known basis for cooperation between content and language teachers. The ESL teacher in this study taught the genre of laboratory reports to her students, as this was something the science department had requested. The science department was familiar with the lab report as part of normal science teaching and recognized that the ESL teacher’s linguistic understanding of this genre could help ELLs.

Register is less known as a basis for cooperation. Register can be understood in part through the simpler idea of *topic*. Texts can vary in genre and in topic: There are narratives and procedures in both English classes and science classes. A register is defined in terms of meanings: “We can refer to a ‘mathematics register’, in the sense of the meanings that belong to the language of mathematics... and that language must express if it is used for mathematical purposes... we should not think of a mathematical register as consisting solely of terminology, or of the development of a register as simply a process of adding new words” (Halliday, 1975, p. 65). The register is a resource for creating meanings, a “meaning potential” which can interpret

and produce texts of the field in context. The science teacher knows the field of knowledge and has already constructed the meaning potential of the relevant area. The learners, however, have to build this meaning potential and learn the discourse of science (see Halliday, 1999).

When teachers assess learners' knowledge of science, in SFL terms they are assessing whether the learners have built up the meaning potential of the science register and can apply it to relevant situations and texts. Mohan and Slater (2005, 2006) found that science teachers create a "theory–practice dynamic" where they guide students to apply general meanings of the register ("theory") to particular tasks for problem-solving ("practice"). They noted how this enabled the teachers to engage in effective formative assessment. In our analysis we trace one aspect of meaning potential—*ideational meaning*—which covers three main realms of experience. Each realm correlates roughly with a main class of verbs: The identification and classification of things, qualities, or processes correlates with verbs of having and being; the representation of events and activity sequences, including cause-effect relations, correlates with verbs of doing and happening; human consciousness, including mental and verbal processes, correlates with verbs of perceiving, thinking, feeling, and saying. We will show how these three realms correlate with the meaning patterns of taxonomy, cause-effect reasoning, and problem-solving/decision-making in science. Our analysis aims to detail the ideational meaning to show the parallel between an ESL science class and a mainstream science class with respect to meanings in the register of science so that the concept of cooperation through the use of tasks can be elucidated.

The study

This study focuses on two classes located in a Western Canadian high school with a population of about 1500 students of which more than three quarters represented Asian

backgrounds. One class was a grade 9 science class, taught by the head of the science department, Mr. Peterson (pseudonym), in a large science lab. The class had 30 students (14 boys, 16 girls), fourteen to fifteen years old, who were native speakers of English or ELLs whom the administration deemed able to use English well enough to take mainstream classes. The other class was ESL science taught by a trained ESL teacher, Ms. Armstrong (pseudonym), who had several years of experience teaching ESL science. This class, held in a general-purpose classroom, had 20 students (15 boys, 5 girls) representing 5 languages (15 Chinese, 2 Korean, 1 Japanese, 1 Arabic, and 1 Spanish).

Whereas Mr. Peterson focused on teaching grade 9 science, Ms. Armstrong's course was created to socialize newly registered ELLs into mainstream science by using grade-appropriate content to improve their ability to use English *for* and *in* science.

Mr. Peterson's perspective

Mr. Peterson described his classes as "teacher centered" with lecture-style presentations and student labs. He acknowledged that with the growing population of ELLs, there have been more students who "need extra help," and that consequently he was "more likely to use more...examples and try to make [the meanings] very clear." He asserted, "I don't want to excessively tone down the language so that I'm not using as much science-oriented language because I'd be doing a disservice to the rest of the class." He claimed that "in order to function in the science class whether there's me or another teacher next year we're going to be using science specific terms and there is a language associated with science... so I think it's very important to be able to understand science specific language just in order to function and to able to use these terms in descriptions and lab reports and all that." Thus, Mr. Peterson believed that teaching

science language was central to teaching science. While he described “the language associated with science” as “science specific terms,” our analysis below of Mr. Peterson’s teaching showed him to be a skillful creator of a science “system of meanings,” which he formatively assessed through problem-solving tasks. (A detailed account of Mr. Peterson’s teaching is in Mohan & Slater, 2006.)

Ms. Armstrong’s perspective

Mrs. Armstrong was an ESL teacher working cooperatively with Mr. Peterson’s science department. She had developed an ESL science course for students whose language skills were insufficient to enter mainstream science. She stated that she chose Grade 8 or 9 materials and simplified the language to make them accessible. She taught them slowly: “I can only teach half the content that a content teacher could.” She aimed to teach her students prerequisite meanings in a responsive way, to “teach them some of the background they will need to be successful in Grade 9 or 10 [science]...and teach language as it comes out of the lesson.” She used problem-solving science tasks similar to Mr. Peterson’s, but at a simpler level. She had the students do the tasks in cooperative learning groups, for the ESL program and the school had systematically implemented cooperative learning.

She noted that the students particularly lacked the academic abilities needed to work with the discourse structures and systems of meaning of the science register. She was well aware of the meaning patterns of taxonomy, cause-effect reasoning, and problem-solving/decision-making in science, having worked on such knowledge structures of register during her master’s degree. She taught a unit on the scientific process that placed these meaning patterns in relation to each other and in context. It is worth noting that in the textbook used by the mainstream class (Beckett

et al., 1995), the process was explained in *cognitive terms* as a list of thinking skills (e.g., classifying, hypothesizing, problem-solving in experiments) rather than *in discourse terms* as discourse structures and meaning (e.g., taxonomy, cause-effect reasoning, problem-solving/decision-making). Ms. Armstrong helped students develop familiarity with taxonomy (classifying) by *explicitly* teaching comparison-contrast and definition with science materials and she similarly *explicitly* taught cause-effect sequences (hypothesizing). With problem-solving tasks, she *explicitly* emphasized both decision-making (concluding) and “problem solving together as groups.” Following these themes, she would usually assess students’ progress according to how well they were organizing their work, and typically set a library assignment where students researched an aspect of the environment, made a poster, did a group presentation, and wrote an essay. Throughout this, she would take opportunities to develop relevant grammar and vocabulary. The examples below show how both teachers worked with taxonomy, cause-effect reasoning, and problem-solving/decision-making and brought them together in a theory–practice relation around a problem-solving task. Note how Ms. Armstrong is not teaching the discourse structures in isolation, but taking particular care to see that the students can work with them effectively in the theory–practice dynamic of the task.

Constructing register meanings in Mr. Peterson’s class: Taxonomy and cause

In a very systematic process, Mr. Peterson taught science theory meanings, guided students to apply them in a problem-solving task, and formatively assessed their performance. In ‘theory’ lessons on physical properties of matter, he created a register framework of meanings: the taxonomy of physical properties of matter, and the effects of these properties. Students were then asked to apply these meanings to a separation task. Three physical properties of matter

central to the problem-solving task were Density, Magnetism, and Solubility. In the following excerpt, Mr. Peterson carefully discusses how density is defined in terms of mass and volume. Later he illustrates the effects of density. Processes of being are in **bold**. Lexis (vocabulary) related to taxonomy is in upper case.

A. Taxonomy: Teaching physical properties of matter: DENSITY

Mr. Peterson: What's DENSITY MEAN anyway? By DEFINITION? Let me say this

SUBSTANCE **is** more DENSE than that SUBSTANCE.

Melvin: How COMPACT it **is**.

Mr. Peterson: Okay you've got the idea. What kind of UNITS does DENSITY use to measure?

QUANTITATIVE PROPERTIES. So if you just ask what **is** the DENSITY of a

SUBSTANCE and I were to tell you, what kind of UNITS might I use?

Student: GRAMS.

Mr. Peterson: GRAMS would **be** a MASS unit. You've got the right start. GRAMS per

amount? **Isn't** it? Per VOLUME or per AREA or what? What do you think?

Student: VOLUME.

Mr. Peterson: So GRAMS per VOLUME then.

B. Cause-effect: Explaining the effects of the properties: DENSITY

Processes of doing are in *italics*. Lexis related to cause-effect is in upper case.

Mr. Peterson: What *DETERMINES* if something *FLOATS*?

Student: DENSITY.

Mr. Peterson: In water. DENSITY... Exactly. So if something *SINKS* in water would you guess

it's more or less DENSE? Uh ICE *FLOATS* just below well... *FLOATS* low in the water... Here's a rubber stopper in water. (Drops it in.) RUBBER's more DENSE than water. Here's a CORK in water. (Takes out the rubber stopper and drops the cork in.) It *FLOATS* quite high... Now... why things *SINK* or *FLOAT* in water is DEPENDENT on DENSITY.

C. Constructing the problem-solving task

Mr. Peterson introduced a task requiring the students to separate a mixture of iron, salt, sand, and gold. He emphasized that students should make a theory-practice connection between the task and the taxonomy of physical properties and their causal relations. He made it clear how students should reason about the separation problem. He distinguished between the “thinking science nine students way” where the students “think physical properties” (i.e., reason like a scientist) and the “extremely tedious way” of sorting particles by their physical appearance (i.e., use “common sense”). He then made the decision-making process clearer: The physical property should distinguish between the substance to be separated and the others. In the starred examples below, Mr. Peterson recasts a student answer so that it clearly states how the physical property separates the substances. In other words, he highlights how the student choice should be justified with an adequate reason that links back to the taxonomy of physical properties. Note that Mike (below) independently justifies his choice in this way (“The gold is more dense”). Processes of human consciousness are underlined. Lexis related to problem-solving is in upper case.

Mr. Peterson: Now your JOB is to SEPARATE them into four piles. How would you do that?

There's the THINKING SCIENCE NINE STUDENT'S WAY... and then there's the extremely tedious “well, you could get a microscope or a magnifying glass

and a pair of tweezers and you pick out all the things”—it’d take you forever!...

THINK PHYSICAL PROPERTIES. What’s the PHYSICAL PROPERTY this stuff has that the others don’t? Stan?

Stan: Use a magnet to separate the iron?...

Mr. Peterson: Right. There’s one. **IRON’S ATTRACTED. NONE of the OTHERS are.
What’s next? What would you do next? Yeah?

Student: Dissolve the salt in water.

Mr. Peterson: Add water. ** the SALT will DISSOLVE. The SAND and GOLD won’t. Good...
Okay what’s next. You’ve got sand and gold...

Keith: Pan for gold.

Mr. Peterson: THINK of a PHYSICAL PROPERTY that SEPARATES the two... How does panning work?...

Mike: Add water to it. And shake it around and the GOLD is MORE DENSE, so it’ll
SINK to the bottom and the SAND will—

Mr. Peterson: But the SAND would SINK too wouldn’t it?

Mike: No. It would SINK but if you keep SPINNING it wouldn’t.

As can be seen from these three data sections above, Mr. Peterson worked with his students to develop the theory meanings of taxonomy and cause-effect, then guided the students to apply these meanings to a problem-solving task that offered an opportunity for formative assessment.

Ms. Armstrong’s ESL science class

Mrs. Armstrong also created a taxonomy of mixtures and discussed separation methods (a means-end form of cause-effect relations). Students were asked to apply these meanings to a

simplified version of the task that Mr. Peterson's class did, which was feasible for them to discuss in cooperative learning groups. The taxonomy Ms. Armstrong set up was different from Mr. Peterson's, and she talked about the effects of mixing substances from a commonsense perspective, rather than addressing the effects of physical properties. Processes of being are in **bold**. Lexis related to taxonomy is in upper case.

A. Taxonomy: Teaching mixtures and their properties (classification/description)

Students read a short text about mixtures:

- MIXTURES **contain** more than one SUBSTANCE.
- PROPERTIES of MIXTURES **are** a BLEND of all PROPERTIES of SUBSTANCES within it.
- MIXTURES can be separated by physical means.
- There **are** two types of MIXTURES: HETEROGENEOUS and HOMOGENEOUS.

About one week later, Ms. Armstrong asked questions to review the definition of a mixture.

Ms. Armstrong: Okay. DEFINITION of a MIXTURE. All right. Give me some CHARACTERISTICS of a MIXTURE then. Okay. A MIXTURE **is** not joined together. Okay. It's not—

Male: Not change PROPERTIES.

Ms. Armstrong: Not change PROPERTIES.

Vicki: By physical means.

Ms. Armstrong: It tends to be separated by physical means. Good. What else?

Vicki: No chemical change occurs.

B. Cause-effect: methods of separation of mixtures

Students did a matching exercise on separation methods. For example, students matched the mixture of iron filings and wood chips with “use a magnet.” They matched sand and water with “let settle.” Later, Ms. Armstrong read from a handout as the students followed. Processes of doing are in *italics*. Lexis related to cause-effect is in upper case.

Ms. Armstrong: “Water is usually seen as a liquid. It is clear. It *mixes* with many things easily.” Okay so it’s easy to *MAKE* a mixture with water. (She asks ‘commonsense’ causal questions). So if you *add* coffee what do you get?

Male: Coffee.

Ms. Armstrong: You get a drink called coffee. Okay. If you *mix* it with salt? If you *put* salt in the water does that *mix* easily? No?

Male: Yes.

Ms. Armstrong: Yes. It does. What about sugar?

Male: Yes.

Ms. Armstrong: You *put* sugar in water it will *dissolve*. Okay it will *mix* easily. All right.

C. Constructing the problem-solving activity (Evaluation/Choice)

Ms. Armstrong did a simplified version of Mr. Peterson’s problem-solving task, with two shorter, similar tasks first. But rather than working on the tasks orally with the class, Ms. Armstrong put the students into small groups, offering assistance as needed, then had them put their answers on the board, which she discussed with them. She did not ask students to relate their answers to physical properties but hinted at the number of steps in the solution in a practical way. Note, however, that she pressured the students to reflect by probing for a reason for each of

the first two answers and asking for a ‘how’ explanation for the third (see starred utterances).

Processes of human consciousness are underlined. Lexis related to problem-solving is in upper case.

Ms. Armstrong: What I would like you to do is WORK TOGETHER as a group and FIGURE OUT how you would SEPARATE these three MIXTURES...
Now we said that a MIXTURE is easy to SEPARATE or at least you can SEPARATE them by PHYSICAL MEANS... (Later.) Number three. Iron filings. Gold. Salt. And sand... (Talks about the appearance of the four components.) So the QUESTION is how would you SEPARATE these?...
Some of you are not too sure what to do. I’m just going to give you this HINT. There’s more than one step... You do one thing and then you do something else. Okay? And then you do something else again. (Later.)
Number three. Now this was a little bit tricky and you did a pretty good JOB. Iron filings gold salt and sand. ‘First USE a MAGNET’. **For what REASON? **Why are you USING a MAGNET?

Fred: Oh because IRON and MAGNETS ATTRACT.

Ms. Armstrong: Okay. So USE a MAGNET to TAKE OUT the IRON. Okay? The MAGNET will ATTRACT the IRON. All the IRON will COME OUT.
All right. Good. Now you just have gold salt and sand. How would you GET RID OF the SALT?

Fred: I think we should write MIX um gold sand salt and water together.

Ms. Armstrong: **Why?

Fred: Cuz uh WATER and SALT can JOIN.

Ms. Armstrong: Okay and then what do you do?

Fred: And then TAKE OUT all the WATER.

Ms. Armstrong: Ah! Okay. So you're going to MIX everything with WATER. Right? The SALT will DISSOLVE in the water. Then you POUR the WATER off. Then you do the same as number two. Right. You BOIL the WATER. The salt is left. Right. Good.... (Later.) Now you're left with the gold and the sand. **How did the old prospectors GET GOLD OUT OF SAND?...

Fred: Put the sand and water into the bowl... SHAKE it and then... the SAND would be on the TOP and the GOLD would be... on the BOTTOM.

When we examine Ms. Armstrong's class, we can see that she used her knowledge of the general science register to help her students develop theory meanings of taxonomy and cause-effect while simplifying the language demands. Like Mr. Peterson, she also guided her students in a problem-solving task, which allowed the students to use their evolving linguistic knowledge to apply what they were learning.

Discussion

This study aimed to show how there was skillful cooperation between Mr. Peterson and Mrs. Armstrong based on the science tasks they selected that applied theory to practice and developed meanings in the register of science. Mr. Peterson carefully presented relevant science theory meanings, gave students detailed guidance to apply them to the practical task problem—a separation task—and formatively assessed how well they understood the challenging science meanings they were working with, not only the specific meanings, such as density, but also the more general meanings, such as taxonomy, cause-effect, and problem-solving.

The language skills of Mrs. Armstrong's students were not adequate for mainstream science. She therefore simplified the task to make it possible for her students to discuss it together through cooperative learning and jointly develop the discourse processes and register meanings that such task types require, applying theory to practice and including taxonomy, cause-effect, and problem-solving. Having an awareness of the general requirements of the science register, she monitored their progress in the cooperative learning of science meanings. In this way she aimed to “teach them some of the background they will need to be successful in Grade 9 or 10 [science].”

This study has also drawn attention to how both teachers use language to conduct formative assessment of their students’ scientific discourse.

Conclusion

From our analysis, it is possible to see how ESL teachers and content teachers can cooperate effectively using content-area tasks in ways that apply theory to practice and help students develop relevant meanings in the register of the content area. If we use the SFL concept of the meaning potential of register, we are able to recognize not only the content teacher’s contribution to language support, but also the contributions to science and language teaching through register development that the ESL teacher provides despite not being a content specialist. If ESL teachers have an awareness of the requirements of the content-area register, and if they guide the cooperative learning by ESL students of appropriately modified content-area tasks, the teachers can provide opportunities for their students to learn these relevant meanings and for themselves to monitor such learning. We believe that in future a focus on

content-area tasks will enable both ESL teachers and content-area teachers to benefit by sharing their knowledge of the register meanings that these tasks require and the language demands that they place on ELLs and by coordinating their approaches to formative assessment.

This article has taken a register perspective on language-and-content cooperation. In our view, future researchers will find it invaluable for revealing the parallels between the work of teachers in the classroom and their processes of cooperation. Researchers will also find it invaluable for analyzing formative assessment processes and ultimately for assessing student development in content-area registers.

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